Research and Management Viewpoint

USING THE NORTH AMERICAN BREEDING BIRD SURVEY AS A TOOL FOR CONSERVATION: A CRITIQUE OF BART ET AL. (2004)

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Abstract: Bart et al. (2004) develop methods for predicting needed samples for estimation of long-term trends from count survey data, and they apply these methods to the North American Breeding Bird Survey (BBS). They recommend adding approximately 40% more survey routes in the BBS to allow for estimation of long-term (i.e., 20 year) trends for a collection of species. We critique several aspects of their analysis and suggest that their focus on long-term trends and expansion of the present survey design will provide limited benefits for conservation because it fails to either enhance the credibility of the survey or better tie the survey to regional management activities. A primary innovation claimed by Bart et al. (2004) is the incorporation of bias in estimation in study planning. We question the value of this approach, as it requires reliable estimates of range of future bias. We show that estimates of bias used by Bart et al. (2004) are speculative. Failure to obtain better estimates of this bias is likely to compromise the credibility of future analyses of the survey. We also note that the generic analysis of population trends that they provide is of questionable validity and is unlikely to be relevant for regions and species of management concern.

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The North American Breeding Bird Survey (BBS) provides a remarkable view of population change of North American bird species. BBS data are used to estimate population change for >400 species and are used as a primary data source for many conservation-related estimation and modeling activities (e.g., Sauer et al. 2003, Thogmartin et al. 2004). Sauer et al. (2003) showed that 72% of 421 species had survey-wide trend estimates that were precise enough to detect a 3%/year change over the interval 1966–2000; hence, it could be argued that the BBS currently does a reasonable job of estimating long-term trends within the surveyed area. However, it is clear that significant uncertainties exist with the present design, and all surveys must be subject to constant review and revision to ensure that they provide reliable information focused on present needs. Discussion of the future of this important survey should reflect sensitivity both to modern uses of the survey and to a realistic approach to accommodating limitations of the present design.

Bart et al. (2004) provide a perspective on future use of the BBS in regional bird conservation. They view estimation of long-term population trends as the primary goal of the survey, and their notion of the future of the BBS is to add survey routes to better meet this goal. To address concerns about the BBS design, they derive a procedure for sample allocation in which magnitude of bias in estimates of trend is specified and accommodated through increased samples. To evaluate trends from the BBS, they use a nominally design-based approach to trend analysis (Bart et al. 2003) for species that they view as well-sampled by the BBS.

The Bart et al. (2004) perspective on the use of the BBS in conservation has 3 critical flaws. First, they present a very limited view of the use of surveys in bird conservation, as they optimize survey design for estimation of long-term trends for arbitrarily defined time intervals and groups of species. Trend estimation should be viewed as one of several possible goals for survey design (e.g., Morrison et al. 2001); more focused goals that tie the survey directly to management activities would better advance bird conservation (Yoccoz et al. 2001, Williams et al. 2002). Second, their procedure for modifying hypothesis tests and sample allocations to accommodate bias is a rationalization of poor statistical methods, and estimates of range of bias that they present and use in the analysis are not credible. Third, we disagree with their statistical analyses and vision for the future of the BBS. The BBS is a critical resource for bird ecology and conservation, but action is needed to ensure its future relevance. Bart et al.'s overly simplistic analy-

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sis and endorsement of the status quo threaten the future of this important survey.

Why Collect Survey Data?

North American bird conservation would greatly benefit from a careful consideration of information needs for conservation and the role of the BBS in meeting conservation needs. Bart et al. (2004) frame goals for survey design in terms of estimation of long-term population trends and develop approaches that rationalize the present design of the survey. However, critical information needs for conservation are likely to be unmet by a focus on long-term trend estimation. The BBS is currently used to derive population estimates (Rich et al. 2004), develop models that relate bird populations to habitat and other environmental features (e.g., Thogmartin et al. 2004), and assess a variety of aspects of population change for >400 species of birds at geographic scales of management interest (e.g., Bird Conservation Regions [BCR]; Sauer et al. 2003). These uses represent an important step forward in how we integrate bird monitoring data into management and conservation, and these uses suggest that future needs for monitoring information will involve: (1) providing estimates of state variables (e.g., abundance) to show where populations stand relative to population goals; (2) estimating change in state variables to permit assessment of the effectiveness of management activities, and (3) providing information for evaluating and improving our models. The latter use corresponds to the use of science in informed management (Williams et al. 2002).

Any reasonable discussion of the future of the BBS should consider how the present design meets these needs and what modifications should be implemented to improve the survey to better meet these needs. An important consequence of these needs and goals for monitoring is that variables reflecting system state (e.g., population size) and estimation of short-term change in populations are often more relevant than long-term trends. Estimation of trend represents an attempt to condense the rich information present in a population trajectory into a single descriptive statistic. Although such a descriptive statistic may be useful for some purposes, it is not likely to be adequate for serious management programs. Waterfowl management (cited by Bart et al. 2004 as a success in conservation based on use of trend information) is based on information about population size, not trend, and indeed long-term trends would not provide adequate information for the existing program (Nichols et al. 1995, Johnson et al. 1997, Williams et al. 2002). Even the use of long-term trends for historical uses (e.g., prioritization for research and management) is suspect. Doak (1995) suggests that detection of trends may occur too late for effective management (see also Green and Hirons 1991, Caughley 1994).

By focusing only on long-term trend estimation in the context of the BBS design, the strategy for expansion of the BBS outlined by Bart et al. (2004) overlooks the potential value of the BBS in bird conservation and raises unrealistic expectations for BBS-style surveys. By adopting the Bart et al. (2004) recommendations, in 20 years we may (see below for method critiques) have additional information for prioritization of species based on trends, but we will have neither improved the survey design (leaving the same uncertainties about the value of the survey) nor have modified the survey to provide any additional information on either why the observed changes might have occurred or what might be done to reverse observed declines.

Bias and Survey Design

Bart et al. (2004) develop an expression for required samples sizes based on biased estimates and apply it to the BBS. Their approach begins with specification of upper and lower limits on bias, and it defines an explicit role for these limits in hypothesis tests based on BBS data. Their approach rationalizes poor statistical and survey methods. Following their recommendations would compromise the future of the BBS, as there is almost no information regarding the ranges of bias in BBS estimates; both the predicted sample sizes and any analyses of population change have no credibility because they depend on unknown quantities.

No Information Exists Regarding Bias in BBS Estimates.—Bart et al. (2004) provide no direct estimates of the magnitude of bias in estimation, even though the sample size estimation procedure and all future analyses of BBS data critically depend on ranges of the bias in estimation. They describe 3 possible sources of bias: roadside effects, observer effects, and analysis method, but they only present estimates of bias in estimates of habitat change (not bird populations) associated with roadside habitats. In the absence of any reported evidence, they speculate that each source may contribute bias of 0.005; they then combine these speculations into a composite estimate of ±0.008 by assuming that, "these biases should cancel out each other to some extent" (Bart et al. 2004:618). Al-

though they acknowledge that the estimate is "admittedly crude" in the text, Bart et al. present this number in their abstract as an estimate without qualification. Presenting this number as a credible estimate in the abstract is an extremely dangerous precedent because many readers may not recognize that it is not based on data. The Bart et al. (2004) discussion can be viewed as an admission that they have no direct evidence of magnitude of bias present in BBS estimates.

Range of Bias Must Be Specified to Implement the Bart et al. Approach.—One of the central problems associated with survey design in biology has been the disconnection between design and implementation of surveys and their analyses. In practice, the Bart et al. (2004) approach explicitly undermines any analysis of future BBS data by demanding the inclusion of quantities that are not estimable. Other uses of BBS data such as modeling, population estimation, and short-term trend estimation are all subject to biased estimation, and they should be considered in evaluation of bias in estimation. Unfortunately, incorporation of ranges of bias is even more problematic for these uses of BBS data. For example, it is likely that range of bias would be interval-specific in trend analyses, with shorter intervals experiencing larger ranges of bias. Responsible stewardship of the BBS requires that we minimize the uncertainties associated with the analysis, and guessing at ranges of present and future bias is not an acceptable scientific strategy.

Improvement of the survey is the only statistically-defensible approach for accommodating the difficulties associated with bias in BBS analyses. Of course, implementation of design features needed to estimate bias (i.e., a spatial design that includes off-road strata and a survey method that permits estimation of detection probability) would preclude the need to incorporate bias into hypothesis-testing schemes.

Flawed Approaches to Trend Analysis

Careful specification of analytical methods, species, regions, and time periods of interest are prerequisites to any useful evaluation of the BBS. Species or groups of species of management interest should be a primary focus; regions of relevance to management should be considered; time periods with intrinsic value to either management or the biology of the species should be selected; and appropriate analysis methods should be used. Without this focus, it is unlikely that the recommendations for expansion of the survey will result in better information for management or conservation. We review some of the choices Bart et al. (2004) made with regard to time periods, species, and regions.

Arbitrary Durations and Magnitudes of Trend.—Estimation of trend is not a meaningful objective unless it is connected to a biological or management-based concern for each species. Without that connection, it is impossible to justify expending limited funds on additional BBS routes when simply modifying the goal to consider a longer time interval or a different magnitude of trend would achieve needed precision with no additional samples. Rather than addressing the issue of what trends and intervals might be reasonable for different species, Bart et al. (2004) instead sidestep the problem by citing goals stated in earlier analyses and then conducting a series of analyses of BBS data to determine feasible magnitudes and temporal durations of trend that could be detected by the present BBS. Determining "Reasonable values of C" (C is the total change in population size; Bart et al. 2004:612) from evaluation of frequency distributions of trend estimates is tautological; reasonableness must be defined in terms of external needs, not observed patterns.

It would be beneficial to consider alternatives to arbitrarily defined decision trigger points that are based on hypothesis tests and derived from characteristics of the sampling program. Adopting a decision-theoretic approach to management, in which management decisions are viewed as dynamic optimization problems, would better tie the monitoring to the models used in management (e.g., Williams 1982, 1989, 1996; Kendall 2001; Williams et al. 2002) and provide a better context for discussions of sample allocations of BBS routes. Modeling activities presently underway that use BBS data could provide a framework for developing the decision-theoretic approach.

Undefined Species.—Careful definition of the species of interest is critical to any collective analysis of groups of species. In the Bart et al. (2004) analysis, trend goals are disconnected from species of management interest. They base their analysis on 133 species that appear on a moderate number of BBS routes rather than on species of management interest, and they set criteria that are based on the eightieth percentile of those species. The species are not defined, and it is difficult to ascertain the relevance of criteria based on these species to present priority species identified by conservation organizations or even to species groups of management interest. This approach

shifts the emphasis away from consideration of individual species or even from a collection of relevant species, and it obscures the fact that many species of management interest tend to be poorly sampled by the BBS. Although all species are theoretically of interest for monitoring, it is prudent to ensure that species of particular management interest be identified and evaluated.

Poorly Defined and Inappropriate Analyses.—Bart et al. (2004) provide little information on how they conducted their analysis of population change, even though these analyses are the source of most of their information. Details such as stratification are mentioned, but apparently stratification is applied at the scale of U.S. Fish and Wildlife Service administrative regions, which are much larger regions than those generally applied in BBS analyses (Sauer et al. 2003). Spatial scale of estimation does not appear to bear any relationship to BCRs, even though BCRs are the scale at which most regional bird conservation and modeling exercises are likely to be implemented. These issues are not trivial details, but they can greatly influence results and should be clearly stated for any analysis (Sauer et al. 2004).

The trend estimation method proposed by Bart et al. (2003) is one primary source of trend and precision estimates used in this analysis. Unfortunately, the Bart et al. (2003) method has serious deficiencies that make its use very risky. Sauer et al. (2004) identified several of these deficiencies. It can be documented that estimates based on this method are biased large, and estimated precisions from the approach are biased small. The bias in estimation is due to the failure of the method to incorporate observer effects, a factor known to influence detection of birds along BBS routes. For the 166 BBS species encountered on >500 survey routes over the interval 1966–2003, it can be shown that failure to include observer covariates leads to estimates of variance that are 45% the size of variance estimates calculated with observer effects (the median ratio of estimated variances = 0.45). If one chooses to ignore strata in the analysis, this ratio is even larger (median ratio of estimated variances of estimates without observer effects or strata to variances of estimates with observer effects = 0.36). By ignoring these features of the analysis, the Bart et al. (2003) method for trend estimation provides variances that are less than half that of an appropriate analysis, and clearly any sample allocation based on that method will greatly underestimate needed sample sizes. Careful evaluation of strata and features (e.g., observer effects) that are likely to influence bias in estimation and controlling for them in analyses (as is done in Sauer et al 2003), is much better than the alternative approach of ignoring these features in the analysis and speculating about magnitude of bias.

Bart et al. (2004) cite Sauer et al. (2001) as the source of some of their estimates of precision. This analysis is fundamentally different from the Bart et al. (2003) method, but nowhere are these differences mentioned. Although the Sauer et al. (2001) analyses incorporate observer differences and strata, Bart et al. (2004) use the estimates to derive ad-hoc estimates of precision for the FWS regions. This scaling is inappropriate (as it requires a random sample of routes) and unnecessary because estimates could have easily been directly computed for the regions of interest.

DISCUSSION

As analysts of the BBS, we have noted with concern that the BBS has lost some credibility in recent years. Some scientists point to flaws in survey design and reject the results and methods of the survey (e.g., Bibby et al. 2000). Managers also are critical of BBS methods and results, and it is informative to read recent Federal Register documents regarding mountain plovers (*Charadrius montanus*; Federal Register 68[174]) and cerulean warblers (*Dendroica cerulea*; Federal Register 67[205]), in which the BBS results are given little credence. For example the cerulean warbler document contains the statement, "We and our colleagues who oversee and analyze BBS data believe that BBS data are of questionable value for reliably determining trends for making listing determinations even for declining mature forest associated species, like the cerulean warbler" (Federal Register 67[205]:65084).

This rejection of BBS data by managers as a source of information on population change should trigger a crisis among conservationists; any discussion of the future of the BBS must address these issues. In light of these concerns, we view the vision for the future of the BBS presented in Bart et al. (2004) as counterproductive to the goal of developing positive approaches to improvement of this important survey. Although Bart et al. (2004) acknowledge the need for improvement in survey methods, their sample allocation methods and recommendations reinforce the status quo of the survey, and it suggests that too-few samples are the primary limitation of the present survey. However, "more of the same" will not improve the qual-

ity of the information, nor will it provide credible estimates of the magnitude of bias in estimation associated with the survey.

Bart et al. (2004:612) have a very limited view of the role of the BBS in management, as exemplified by their statement that management actions "will not—and cannot—be designed" until causes of declines are identified. This is simply not true; management activities are constantly being implemented at local (e.g., National Wildlife Refuges) and regional (e.g., BCR) scales. These activities provide an opportunity to learn about the effects of management on bird populations, and a critical need exists to evaluate how present surveys such as the BBS are suited to provide these assessments and, if necessary, recommend more efficient designs that could provide more useful information. One of the most interesting and forward-looking aspects of analysis of BBS data is an increasing ability to model spatial and temporal covariates of population change, and hence to gain insights into factors associated with change (e.g., Royle et al. 2001, Thogmartin et al. 2004). These modeling exercises provide an opportunity for initiating the process of dynamic use of survey data in increasing our understanding of factors influencing bird populations.

Bart et al. (2004) provide a service to conservation in noting that unmodeled factors that influence estimates of population change should be considered in future planning for the BBS. However, the flawed estimates of present bias in the survey they provide are of limited use in planning future surveys, and their discussion clearly demonstrates how little we know about the magnitude of bias in estimation in the BBS. They also demonstrate how critically dependent future analyses of the survey will be on obtaining better estimates of these biases. We encourage dialogue on improving the BBS and enhancing its value to bird conservation, and we hope that this commentary continues this process by focusing on the need to reduce some of the uncertainties associated with BBS analyses.

MANAGEMENT IMPLICATIONS

All surveys must be routinely evaluated to ensure that they meet information needs and conform to present standards for survey design. Discussions of increasing the numbers of BBS routes must focus on goals, geographic scales, and analytical methods that assist in integrating the BBS into regional conservation activities. BCRs are generally considered an appropriate scale for modeling and management, and the BBS has a critical role in providing information for developing models and population assessment within BCRs. We suggest that design recommendations for the BBS should be focused on enhancing the value of the information for modeling exercises and on providing better information for both defining population goals for conservation and evaluating population status relative to those goals.

A need also exists to document, estimate, and control for bias in estimation from the BBS. Many opportunities exist for meeting this need, including (1) field studies to estimate detection rates for specific sampling situations; (2) use of modeling using ancillary data such as remotely sensed habitat data to better control for detectability and accommodate roadside sampling issues; and (3) implementing judicious changes in the design and protocols of the BBS. Implementation of additional sampling protocols on a subset of BBS routes would not be difficult, as methods such as removal sampling (Farnsworth et al. 2002) require minimal design modification. Professional biologists are a significant (and increasing) proportion of BBS observers, and they could be recruited to implement the methods. In addition, information is needed for off-road habitats both in northern Canada and in the continental United States. Developing and sampling these off-road strata will be an essential part of a complete North American breeding bird survey.

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